

CHAPTER 5

EPISTEMIC GAMES

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Abstract

This article profiles an important class of generic cognitive structures, “epistemic games.” These are general patterns of characterization (e.g., verbal description, algebraic notation), explanation (e.g., covering-rule explanation, analogical explanation), and justification (e.g., deduction, statistical justification) that inform inquiry within and across disciplines. They are necessary although not sufficient for effective inquiry, and learners often have trouble with them. Their importance challenges a highly situated view of cognition, but with qualifications. Epistemic games often constitute areas of expertise in themselves, and often assume distinctive styles within disciplines. © 1997 Elsevier Science Ltd

The quest for clarity, understanding, and truth unfolds in innumerable particular stories from day to day. For an example from the world of science, the notion of cold fusion saw a brief sunrise in 1989 as Martin Fleishmann and B. Stanley Pons claimed findings that demonstrated excess heat and fusion products in an amazingly simple apparatus, an electrolysis device that dissociated heavy water into deuterium and oxygen at a palladium cathode and platinum anode respectively. Fusion supposedly occurred in the palladium cathode as the deuterium atoms packed closer and closer together within its crystal lattice.

Unfortunately, other scientists’ efforts to replicate the results these investigators obtained proved futile. In the end, the conception of cold fusion sank beneath a barrage of empirical and theoretical criticism. In this and thousands of other circumstances from court rooms to senates to newspapers to professional journals, puzzles about the way the world is and how to explain it play out every day.

While one can focus on the nuances of each such story, some commonalities are plain — the appeal to evidence of one sort or another, the use of logic to relate theories to evidence, the role of formal or informal narratives to provide coherent accounts. It is worth asking what these patterns of inquiry and how they empower people to engage in inquiry.

The notion that broad patterns of thinking can organize inquiry and help it toward success is ancient. Aristotle in his *Analytica Priora* sought to systematize logic into the syllogism around 350 B.C. Francis Bacon (1878) proposed rules of scientific inference, what has often been called

the “scientific method.” The German philosopher Ernst Cassirer (1953-57) saw in the general symbolic structures used by people ways not just of encoding the world but generating insight:

It is one of the essential advantages of the sign... that it serves not only to represent, but above all to *discover* certain logical relations—that it not only offers a symbolic abbreviation for what is already known, but opens up new roads into the unknown (p. 109).

Aristotle, Bacon, Cassirer, and many others encourage recognizing what might be called higher-order knowledge — knowledge of such a general sort that it concerns no particular object or field but helps to organize inquiry into a wide range of fields. Higher-order knowledge might be the wizard’s secret of intellectual accomplishment across a range of fields.

However, according to contemporary critics, this wizard is more like the Wizard of Oz, a charlatan with little real power. Hirschfeld and Gelman (1994) note the history of faith in the wizard: “According to a long predominant view, human beings are endowed with a general set of reasoning abilities that they bring to bear on any cognitive task, whatever its specific content” (p.3). However, they point out that in recent years a number of researchers from different quarters have challenged this entrenched view. On the contrary, cognition may be context specific in several senses, reflecting domain-dependent neural modules, hard-wired presumptions about what the world will be like, tacit lay theories, and the rich nuanced knowledge base of expertise.

Brown, Collins, and Duguid (1989) warn against the “abstract, decontextualized formal concepts” (p. 32) that make up much of conventional curricula. They urge that knowledge is inherently situated in contexts of activity such as professional practice in a domain.

...knowledge, which comes coded by and connected to the activity and the environment in which it is developed, is spread across its component parts, some of which are in the mind and some in the world much as the final picture on a jigsaw is spread across its component pieces (p. 36-37).

Their view challenges the meaningfulness of higher-order knowledge and castigates typical education for dealing too much in it.

These and other arguments make an important point: Often abstractions get taught in acontextual ways that leave learners clueless about concrete situations. However, others have argued that the case for situated knowledge can go too far: Higher-order knowledge, suitably linked to content knowledge, can play an important role in thinking (e.g., Baron, 1985; Ohlsson, 1993; Perkins, 1992, 1995; Perkins & Salomon, 1989; Salomon & Perkins, 1989; Sternberg, 1985). The aim here is to identify and defend the importance of a particular kind of higher-order knowledge, a broad class of patterns in thinking called *epistemic games*. Epistemic games play a key role in everyday and technical inquiry.

The Idea of Epistemic Games

When people engage in investigations — legal, scientific, moral, political, or other kinds — characteristic moves occur again and again. An anthropologist, a literary critic, or an astronomer may profile an observation in words or classify it into a category system. A judge, a sociologist, or a philosopher may explain something by analogy or explain it as the lawful outcome of a general rule applied to a particular case (covering rule explanation). A physicist, a historian, or a

lawyer may justify a conclusion by appealing to one critical observation or an aggregate of observations with a statistical trend, as in DNA testing. Indeed, a practitioner of any of these professions might proceed at one time or another in almost any of these ways.

Diverse as categorization, analogy, covering rules, and so on may seem, it is not hard to identify some common features. Focus for a moment on the building and use of category systems. This commonplace tool of inquiry involves certain forms or schemes — the categories themselves and the attributes employed for classification. There are characteristic moves to make — most centrally, classifying, but also adding, subtracting, and adjusting categories if the aim is not just to use but to build the taxonomy. There are goals — an item well classified or an entire category system well-constructed. There are informal or formal rules — consistency of classification and such general criteria for a good category system such as comprehensiveness and uniqueness of classification.

The same notions of forms, moves, goals, and rules apply to any of the patterns of thinking mentioned. For instance, explanation by analogy takes the form of a target to be explained, the source analog, and a map between them that preserves important structural elements (Gentner, 1983, 1989). Moves include proposing and detailing the source analog and the map. The goal is fruitful explanation. One rough rule for explanatory analogies is that surface properties of the source may map into very different surface properties of the target, but patterns of relationship should be preserved. For instance, if A causes B in the source, the image of A should cause the image of B in the target.

For another example, statistical justification typically takes the form of an inference from a random sample with estimates of the risk of a mistaken conclusion by chance. It involves moves such as selecting the sample, extracting measures of central tendency, and calculating estimates of risk. Statistical justification has the goal of a conclusion established within a degree of risk deemed appropriate for the field in question. For example, the .05 level of significance conventionally considered sufficient for results in psychological investigations would be laughed out of any U.S. court as an inadequate level of significance for DNA testing because it leaves too much room for “reasonable doubt.” Finally, statistical justification observes rules such as avoidance of biased samples.

For still another, a mathematical covering rule explanation — for instance, in physics or economics — takes the form of a set of constraint equations claimed to hold for the system in question. Moves include formulating such constraint equations based on prior theory and initial observations and specifying the map between the parameters of the constraint equations and observable characteristics of the system. The goal is to explain the behavior of the system through a mathematical model that accounts for prior system behavior and predicts future system behavior. Rules include the mathematical rules applicable to the constraint equations and to generating inferences from them.

To summarize, what inquirers do to investigate something can be in part characterized as a somewhat regular pattern of action analyzable into forms, moves, goals, and rules. The pattern recurs across particular content within a domain — and often across domains — so people can be said to be following the same or a very similar pattern of action even when investigating different things.

It is useful to have a name for such patterns of inquiry. They will be called *epistemic games* (cf. Collins & Ferguson, 1993; Perkins, 1994). Their characteristic forms of outcome — arguments, analogies, classifications, and so on — can be called *epistemic forms*. In part, the term *games* is suggested by the conspicuous involvement of goals, moves, and rules; in part by

the recognition that these patterns of inquiry are not static templates but action systems; in part by the fact that often epistemic games are played competitively, as in the adversarial system of justice or scientific debates; and in part in allusion to Wittgenstein's notion of language games (Wittgenstein, 1953). To be sure, the game metaphor is not entirely apropos. For instance, real games like chess and soccer are played at different times, but epistemic games are woven together in the course of an inquiry. Nonetheless, the term is evocative.

For all that, *epistemic games* is just a stipulated label. What is central is not the name but the nature of these patterns of inquiry. They inform inquiry at a more general level than particular facts or theories. They are not claims about the world but rather regularities in how we progress toward knowledge and understanding. Darwin's theory of natural selection is not an epistemic game, but the generalized Darwinian pattern of explanation, applicable to many evolution-like phenomena, is (Ohlsson, 1993). Maxwell's theory of electromagnetism as expressed through his equations is not an epistemic game. But the enterprise of constructing a model through constraints expressed by equations is. The Magna Carta and the United States Constitution are not epistemic games. But the process of stipulating principles to govern a people is. Epistemic games, unlike theories, make no claims. They are neither true nor false but may prove more or less often applicable and illuminating.

Are Epistemic Games Really There?

Naming something does not make it real. Speaking of unicorns does not bring them into being. While epistemic concepts like reason, explanation, analogy, and so on, plainly figure in inquiry, perhaps they do not hang together in the patterned way suggested by the notion of epistemic games. Perhaps inquiries consist simply in "epistemic salads," conglomerates of epistemic elements without any of the game-like structure proposed. Are epistemic games really there?

Here it is useful to address an easier and then a harder case — first *explicit epistemic games*, recognized and talked about as patterns of inquiry, and then *tacit epistemic games*, recognized implicitly by practitioners who may not talk about them abstractly as patterns of inquiry.

Many epistemic games are explicit. Psychology students learn about statistical inference. Law students learn about legal reasoning. Students of anthropology learn about different perspectives on how to do anthropological research and how to validate anthropological claims. Students of formal mathematics learn about how definitions and axioms lead through deduction to lemmas and theorems.

Such studies are not just theoretical but practical. The aim is not to describe statistical inference, legal reasoning, or anything else from afar, as a sociologist or historian might, but to reflect and inform practice. There is an explicit pragmatically-oriented metadiscourse about the pattern of inquiry in question, addressing its forms, moves, goals, and rules. In such cases as these, the reality of an epistemic game can hardly be in doubt, since it is recognized explicitly in the metadiscourse of the field.

However, not all epistemic games are played with a conspicuous metadiscourse. For example, in everyday informal argument, people give reasons for claims, challenge questionable evidence, and so on. They may even use terms like "argument" and "evidence." But typically they have little to say about argument as such or its organization. Or, for a more technical example, constraint equation models occur over and over again in science, from $F=MA$ to Ohm's law to Boyle's law and beyond. Yet there is usually no general metadiscourse about the forms, moves,

goals, and rules of such models. Students just take them one by one and learn to deal with them. In such situations as these, the epistemic game if present at all seems to be tacit. What kind of a case can be made for its reality?

Two different arguments apply, philosophical and empirical. On the philosophical side, analysis of such candidate games demonstrates their coherence and denies the “epistemic salad” alternative. Consider again informal everyday reasoning. As with more formal reasoning, everyday reasoning can be analyzed in terms of claims, the reasons supporting the claims, the warrants connecting reasons to claims, and related concepts (Toulmin, 1958; Toulmin, Rieke, & Janik, 1979). Such constituents occur explicitly and tacitly in argumentative discourse whether participants name them or not. And from a logical standpoint they must occur in certain patterned relationships. An argument is not an argument without reasons advanced in support of a claim. To lend support to a claim, a reason must do so by way of a tacit or explicit warrant. So claims, reasons, and warrants are not epistemic elements that can combine in any old epistemic salad. To be claims, reasons, and warrants, they have to relate to one another to form an argument structure. This illustrates in one case what holds in others as well. Epistemic elements such as reason, hypothesis, theory, explanation, and so on do not combine in any old way. They play distinctive roles in coherent systems that support inquiry — in epistemic games.

Such an argument appeals to our linguistic intuitions about the meaning of terms like claim, reason, hypothesis, and theory. But are those intuitions sound? What empirical evidence might there be that people observe such patterns in their inquiry behavior rather than producing epistemic salads?

Consider again the case of everyday argument. Ideally, a reason both appears sound in itself and lends support to a claim. Are these criteria observed? Do people advance reasons indifferent to whether the reasons appear sound in themselves? Certainly not. People assert reasons intending or hoping they will be taken as true or defensible. And when people assert reasons of dubious truth, do others indifferently accept those reasons? No, they offer challenges. As to support relationships, do people advance reasons with no discernable support relationship to the claim? Of course not. And when people advance reasons with questionable support relationships to the claim, do others play along? No, they often challenge the support relationship.

This empirical pattern in people’s argumentative behavior has been offered as an appeal to common knowledge. For skeptics who doubt this common knowledge, formal experiments could be done. One could sample argumentative discourse and record instances of blatantly questionable reasons or reasons that stand in no obvious support relationship to the claim in question. The prediction is that their frequency would be low. One could pose arguments with such anomalies and see whether people complain and what they complain about. The prediction is that they often should advance objections that amount to complaints about implausible reasons and questionable support relationships. Such findings would provide formal evidence that people tacitly understand and comply with important aspects of the epistemic game of everyday argument.

As a pattern of validation for the reality of tacit epistemic games, all this bears analogy to testing whether a language has a certain grammar. Speakers of the language may rarely or never engage in metadiscourse about the language’s grammar. Nonetheless, regular patterns appear in speech. Further testimony to the reality of the patterns accrues when native speakers challenge and correct anomalous utterances.

Another more technical example may help to make the case. A more specialized epistemic game mentioned earlier was constraint equation models. Here again, there is generally little metadiscourse. However, both philosophical and empirical considerations argue for a coherent

epistemic game rather than an epistemic salad. Philosophically, the very meaning of a constraint equation model entails basing particular explanations and predictions on mathematical inferences from the constraint equations. Validity of the model depends on the match with the behavior of the modelled system. Occasional and irregular mismatches with predictions may be dismissed as noisy data, but systematic mismatches suggest an incomplete or even fundamentally mistaken model. All this is part of the very un-salad-like logic of constraint equation models.

On the empirical side, the question becomes whether people who have had a reasonable opportunity to learn this epistemic game in fact behave in ways that respect its putative pattern. And again, to a considerable extent they certainly do. Students familiar with constraint equation models but new to a particular constraint equation model — say, Ohm's law — will show appropriate behavior. For example, well-known research on physics novices shows that, asked to derive a particular value, they commonly "reason backwards," finding an equation that yields the target value and then trying to find other relationships that connect the terms of the equation back to the givens of the problem (e.g. Chi, Glaser, & Rees, 1982; Larkin, McDermott, Simon, & Simon, 1980a, 1980b). While reasoning backwards is a mark of the novice rather than the expert and shows limited understanding, it nonetheless reveals some appreciation for what the constraint equation model is supposed to do. The model constrains what can happen in the system, so to determine what *does* happen in a particular instance, one needs to connect the target value with the givens via the model — whether by reasoning backwards or forwards. As students learn to recognize typical situations around Ohm's law, they will shift to reasoning forward with the same constraint equations.

What Kinds of Epistemic Games are Played?

There seem to be only three kinds of epistemic games — characterization, explanation, and justification. Relatedly, Ohlsson (1993) suggests three classes of what he terms "abstract schemas," descriptive, explanatory, and compositional, the first two aligning with those suggested here. Each of the three can be played in a general informal undifferentiated way or in various specialized ways.

Generic characterization involves any informal effort at description or more broadly representation by pictorial or other means. For instance, one may informally describe a person, an idea, a landscape, an experience using whatever vocabulary everyday language affords. Typical if rough criteria for characterizations ask them to be accurate, penetrating, and relevant to the larger mission at hand.

Besides generic characterization, there are numerous more specialized techniques of characterizing — category systems (as in the periodic table), strict taxonomies (the taxonomy of plants and animals), quantitative languages like arithmetic, measurements using standard units, algebra, and more. They seem much the same as what Carey (1985) terms "tools of wide application." While generic characterization does not focus on any one of these, more technical discourse often does, and generic characterization may dip briefly and informally into them.

Generic explanation involves informal and undifferentiated efforts to account for something. The basic relationship is that of explanans to explanandum: the explanans explains the thing about which we are puzzled, the explanandum. In informal explanation, there may be tacit appeal to analogies, covering rules, or the like, but not in any technical or tightly reasoned way. Even so, tacit criteria come into play. An explanation should not be circular, for instance, simply

repeating the phenomenon to be explained. The explanans should invoke principles somehow deeper, more basic, or more general than the explanandum, else we do not experience the explanans as explanatory.

Besides generic explanation, there are numerous specialized explanation games, for instance explanation by analogy in a more explicit way that spells out the analogical relationship, by covering rules, by constraint equations, by atomic decomposition, and so on. Each of these games has its own more specialized rules and own style of play. Again, generic explanation does not exercise such games in a formal and elaborated way but may dip into some of them passingly and without technical apparatus.

Likewise, justification in its most informal shape simply involves the asserting of reasons in support of a claim, with no particular constraint on or identification of the kind of reasons or the nature of the support relationship. The principle criteria are that the reasons are sound in their own right and stand in adequate support of the claims. Played generically, justification does not involve explicit articulation of principles for sound reasons and telling support relationships, although it may involve situation-specific challenges to the adequacy of either.

Again, numerous more specialized justification games get played with more specific and articulate criteria for the adequacy of the reasons and support relations — for instance, formal deductive reasoning with its pattern of premises and axioms supporting strictly deductive conclusions; or legal reasoning with its pattern of arguing from written laws and precedents of their application to the case at hand. Generic justification commonly invokes briefly and passingly the more formal apparatus of specialized justification games, for instance calling something improbable without quantification or complaining that something does not follow logically without reference to rules of inference.

Why do characterization, explanation, and justification play such key roles in inquiry? Their importance is pretty much a matter of logical necessity. When people inquire into something, they need to construct some kind of statement or other representation reporting on it — a characterization. Often, although not always, people are concerned to understand it, not just profile it: They need an explanation of it or aspects of it. Finally, the claims that are made and the explanations that are offered about the thing may be questionable, so justification is needed.

If characterization, explanation, and justification are plainly necessary, what about other processes like decision making or problem solving? Are they also epistemic games? Not according to the present analysis. To be sure, decision making, problem solving, and like processes inevitably figure in conducting an inquiry. One has to decide how to approach the inquiry, for instance. Yet decision making, problem solving, and like kinds of thinking do not have specifically epistemic goals — goals of building knowledge and understanding. Many decisions we take or problems we solve have no specific epistemological agenda. It is the specifically epistemological agenda of characterization, explanation, and justification that recommends identifying them as the three broad types of epistemic games, with their numerous specialized forms.

It is worth noting that the world of epistemic games might be parsed in other ways. For instance, Collins and Ferguson (1993) suggest three broad categories: structural analyses (e.g., compare and contrast, cost-benefit analysis, hierarchies, axiom systems), functional analyses (e.g., cause and effect, form and function), and process analyses (e.g., system dynamics models, constraint systems). This organization, interesting in its own right, groups games somewhat differently. The characterization-explanation-justification scheme would classify compare-and-contrast as a characterization game and axiomatic systems as a justification game, whereas

both fall into the structural analyses category of Collins and Ferguson. No doubt both schemes are workable. The characterization-explanation-justification scheme gets preference here because it stands closer to the process of inquiry with those three conspicuous aspects.

How Do Epistemic Games Relate to One Another?

If generic characterization, explanation, and justification sit at the top of the family of epistemic games as the most global and least differentiated types, how are more specific epistemic games organized underneath them? Specialization is one important relationship. Epistemic games collectively form a rough hierarchy of specialization. For instance, strict category systems (comprehensive and exclusive categories) are one specialization of characterization. Taxonomies with their tree structure and cross-classification systems (where items get classified on more than one dimension, creating cells) can be seen as more elaborated and differentiated versions of simple category systems. Concerning explanation, differential equations modeling a phenomenon are a special case of constraint equations which are a specialized version of covering rule explanations which are a special case of explanations generally.

One specialization of justification is formal logic. Underneath formal logic sit other more specialized styles of that game such as the propositional calculus, the syllogism, and symbolic logic with quantifiers. Another specialization of justification is statistical justification based on samples, with a number of more specialized variants such as *t*-tests, analysis of variance, correlational analysis, and hybrids like analysis of covariance.

Epistemic games often invoke others — in the midst of a characterization one may need to explain or justify something. Therefore, it is natural to ask whether the relationship of “calling upon” discloses a regular pattern among epistemic games. Here the answer seems to be no. One game may need to call upon almost any other, depending on the circumstances that crop up, and often a more specialized game may call upon a game of quite a different character and much less specialized. In the midst of a statistical analysis of the distribution of potsherds across several sites, one may run into questions about whether the sites were accurately recorded, calling for a characterization of the note-taking method and a justification of the practices, very different enterprises than the statistical analysis where one began.

Accordingly, the specialization hierarchy of epistemic games does not provide a map of how one game calls upon another in the process of inquiry. Rather, the specialization hierarchy is best seen as a clarification of the landscape of epistemic games, not as any kind of description or prescription of practice.

How Important are Epistemic Games to Inquiry?

Epistemic games have to do with inquiry by definition. But to say as much is not to say just what role they play. Perhaps epistemic games are incidental accompaniments of inquiry rather than essentially involved.

Here, the three fundamental types of epistemic games identified earlier — characterization, explanation, and justification — help to show that epistemic games play a central role in fruitful

inquiry, not just an incidental one. What would an inquiry be like with no concern to characterize target phenomena, offer explanations, or justify conclusions? There would be nothing left recognizable as inquiry.

More specifically, epistemic games guide the process of inquiry. They point the way toward discovery and verification. When investigators know what kinds of characterizations figure in a field (e.g., numerical measurements of physical quantities in physics, the rich descriptions of anthropology), what forms explanation takes (e.g., constraint equations in physics, the kinds of social structures posited by anthropologists), and how to justify conclusions (e.g., testing numerical predictions in physics, looking for consistency across diverse rich observations in anthropology), this helps them to know what to look for and how to go about looking for and verifying it.

As these examples suggest, there is a bond between the demands of particular disciplines or professions, as they have been socially constituted, and epistemic games. One can hardly function as a mathematician without facility in handling axiomatic systems and deductive proofs. One cannot deal with the law in any serious manner without facility in dealing with rule and precedence-based reasoning. While some disciplines and professions may not demand mastery of highly specialized epistemic games, other disciplines and professions plainly do.

So epistemic games are necessary for inquiry and help to guide it. However, they are not sufficient for good inquiry. Certainly no single epistemic game suffices for fruitful inquiry. For example, hypothetico-deductive reasoning (deducing predictions from an hypothesis and subjecting them to empirical test) plays a key role in scientific inquiry as a justificatory epistemic game. But, as has often been pointed out, hypothetico-deductive reasoning says nothing about how to discover a generative hypothesis.

Ensembles of epistemic games come closer to sufficiency. For example, while hypothetico-deductive reasoning in itself does not point the way to discovery, an ensemble of characterization, explanation, and justification games appropriate to a discipline like physics offers much more guidance.

However, such ensembles still fall short of sufficiency. Attempting to play one or another epistemic game in no way assures meeting its criteria, and even meeting its criteria in no way assures achieving an epistemic form that proves illuminating or compelling rather than merely adequately crafted. Moreover, paradigm-changing inquiry can involve adjusting or shifting epistemic games rather than working with the established ones (Kuhn, 1962). In sum, epistemic games guide inquiry in powerful ways. But they can hardly guarantee its fruitfulness.

Is Playing Epistemic Games Challenging?

Perhaps people developing skills within a discipline master its epistemic games as readily and intuitively as youngsters master the syntax of their mother tongues. If so, as psychologists and philosophers we could look at epistemic games with interest, but as educators we need not worry about them. Unfortunately, life is not so gracious. A number of findings from diverse directions show that epistemic games often trouble learners.

The general epistemic game of justification involves relatively undifferentiated efforts to assess a claim, bringing forth reasons pro and con and offering an appraisal of the likely truth of the claim. A considerable body of research argues that people do not handle such contexts of informal argument especially well. Perhaps the single most troublesome problem has been called “my-side

bias", the predilection to muster evidence on a preferred side of the case while largely neglecting the other. A number of researchers have documented such a trend (e.g., Baron, 1991; Baron, Granato, Spranca, & Teubal, 1993; Perkins, 1995; Means & Voss, 1996). It has been shown that people are not so much incapable of constructing other-side evidence as neglectful of it; they can readily elaborate it if prompted to do so (Perkins, Farady, & Bushey, 1991). Findings suggest that my-side bias is independent of psychometric intelligence; people with high IQs display it just as much as people with lower IQs (Perkins et al., 1991). Finally, my-side bias and other problems of justification are not straightforwardly influenced by knowledge of the area in question. People who for one reason or another have had the chance to develop superior skills of argument may well reason about an issue better than people who are more knowledgeable in the domain (Kuhn, 1991).

Statistical reasoning is a more specialized epistemic game of justification with a track record of problems. The very fact that courses are commonly taught and students labor through them with mixed success testifies to the challenging character of statistical reasoning. Moreover, investigations demonstrate that misconceptions commonly plague learners post-instruction and that learners often do not transfer the understanding attained from formal instruction to less typical instances, although they do to some extent and instruction attentive to the problems of transfer can help them to do so better (Nisbett, 1993).

Reasoning within axiomatic systems is another documented trouble spot. Chazen (1989) showed that students of Euclidean geometry, after considerable conventional instruction, were often profoundly confused about the relationship between proofs and truth. Asked whether they might find exceptions to a theorem that had been formally proved, they answered that yes, they might if they looked hard. Asked what their conclusions might be about a general geometric claim that held up across several diverse examples, they said it surely would be true. In other words, they had the cannon of formal geometry just backwards: Deductive proof did not establish a secure conclusion, whereas a few examples did.

Numerous other epistemic games have been argued to puzzle and confuse people, including control of variables (Wollman, 1977; Wollman & Chen, 1982), analogical and cause-effect reasoning in history (Carretero & Voss, 1994; Neustadt & May, 1986), the generalized generation-selection mechanism, of which Darwin's theory of natural selection is one instance (Bishop & Anderson, 1990; Greene, 1990), system-theoretic and cybernetic explanations with emphasis on properties like homeostasis and delayed reaction (Senge, 1990), dialogical reasoning that asks people to reason across conflicting frames of reference (Basseches, 1984; Paul, 1986), and formal deduction, subject to such errors as affirming the consequence (Evans, Newstead, & Byrne, 1993).

Perhaps these examples suffice to suggest that epistemic games often give people trouble. Nisbett (1993) in his *Rules for Reasoning* sums up the situation nicely with reference to several kinds of reasoning: In supportive conditions and with simple kinds of reasoning, people show a basic understanding and competence. But when the situation less obviously calls for a particular kind of reasoning or the demands become more technical, performance deteriorates dramatically. However, instruction can help. Nisbett summarizes evidence that direct efforts to instruct students in rule systems can enhance performance and transfer.

Higher-Order Knowledge With a Twist

The argument so far can be summed up as follows. Epistemic games are an important area of higher-order knowledge. Epistemic games range from the generic games of characterization,

explanation, and justification as they play out in everyday contexts to highly specialized games such as taxonomizing, explaining with mathematical constraint systems, and statistical justification. Epistemic games cut across disciplines and professions in their more general forms and belong preferentially to clusters of disciplines and professions or even particular ones in their more specialized forms. Some epistemic games are recognized and treated as special areas of knowledge, skill, and understanding in themselves, regardless of the content to which they are applied.

Epistemic games are a necessary condition for effective inquiry, although certainly not a sufficient one. Inquiry cannot proceed without them, and inquiry in many professions and disciplines cannot proceed without recourse to specialized epistemic games. Finally, epistemic games are often badly played. People suffer from misconceptions and display misuses, even after pointblank instruction. Collectively, these points make a case for an important kind of higher-order knowledge.

All this stands firmly against a highly situated view of knowledge and cognition. Such a view holds that little of a general character informs discovery and problem solving in particular domains and subdomains. Each context exerts its own nuanced demands and must be met largely in its own terms. The prominence of general and semi-general epistemic games in inquiry contradicts this position.

With that established, it must also be said that a more moderate situated view sits comfortably with the notion of epistemic games. One basic point is that people never play epistemic games in the abstract but always in particular situations. Epistemic games afford little leverage without a rich base of situational knowledge to operate upon.

Another is that within particular areas of application, epistemic games take on domain-specific nuances. What counts as a precedent in legal terms is importantly different from what counts as a precedent in making rules for one's children, even though in both legal and home settings one needs to draw on precedents and be cautious about setting them. As noted earlier, what counts as statistically adequate in the social sciences may be quite insufficient in a courtroom with its qualitative standard of "beyond reasonable doubt." In general, the play of essentially the same epistemic game in a new domain involves learning its local style.

Finally and most interestingly, epistemic games themselves often involve extensive nuanced knowledge, apart from knowledge of the domain of application. Statistical inference is a transparent case in point. But even the generic epistemic games pose considerably complexity and diverse challenges. For example, informal justifications can call for attentiveness to the other side of the case, to risks of setting unfortunate precedents, to qualitative estimates of probability (that something is unlikely or far less likely than something else), to avoiding the error of sunk costs, to inaction as itself an action for which one is responsible, and of course much more. In every one of the cases mentioned, a series of studies by Baron et al. (1993) showed that students of ages from 7 to 15 by and large neglected these considerations.

An idealized picture of higher-order knowledge holds that there are only a few basics. A simple formula for education might say: Take a week to empower students intellectually by teaching them those basics. But the nature of epistemic games suggests nothing of the sort. While a close consideration of how epistemic games are best learned and taught is beyond the scope of this chapter, it is plain that no simplistic model will serve. Epistemic games involve complex conceptual, belief, and action systems that have to be learned not only reflectively but through diverse experience. They constitute impressively intricate domains in themselves with all the characteristic challenges of attaining expertise. Their acquisition will benefit from "cognitive apprenticeship" (Collins, Brown, & Newman, 1989), the continuous cognitive

investment of "progressive problem solving" (Bereiter & Scardamalia, 1993) or the steadfast "learning your way around" that leads to "knowing your way around" a domain (Perkins, 1995).

That some epistemic games are complex enough to constitute rich domains in themselves does not deny their status as higher order knowledge. Epistemic games inform and guide inquiry in profoundly important ways within and across domains. Law, science, mathematics, history and innumerable other studies would be profoundly impaired without the sophisticated epistemic games that inform them and often cut across them. True, epistemic games are not any Wizard's magic in any Oz of inquiry-made-easy. They do not automatically unlock the puzzles of humankind or the universe. But they do constitute a powerful set of levers behind the curtain of inquiry.

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Biography

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